STUDIES ON THE GROWTH AND FOOD OF THE CARP *Puntius sarana* Ham FROM THE RIVER YAMUNA IN NORTH INDIA

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Sections
1 ENTOMOLOGY
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Date..17th December 19[illegible]

I hereby certify that Mr. Farough [illegible] has been undertaking studies on the growth and food of the carp _Puntius sarana_ Ham. from the river Yamuna in North India under my supervision. This is his own original research work and is suitable for the submission for the award of the degree of Master of Philosophy of the university of Aligarh.

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C O N T E N T S

CHAPTER - I

THE BIOLOGY OF A CARP, *Puntius sarana* OF THE RIVER YAMUNA.

GENERAL INTRODUCTION

An acquisition of complete knowledge of the biology of fish and its inter-relationship with its physical and biological environment is extremely useful to formulate management measures of fishery for its judicious exploitation in an aquatic ecosystem. This knowledge of the biology of fish also helps in accelerating the productivity of aquatic ecosystem. So now-a-days fishery scientists have rightly been paying their attention to various aspects of the biology of fish.

Various aspects of the biology of major carps from the reverine ecosystems have been investigated by Indian scientists (Jhingran, 1952, 1957, 1959; Natrajan and Jhingran, 1963; Kamal, 1969; Rao and Rao, 1972; Khan and Siddiqui, 1973; Pathak, 1975). Attempts have also been made to investigate some aspects of the biology of a few minor carps (Mookherjee et al., 1947; Chacko and Kuriyan, 1948; Das and Moitra, 1955; Moitra, 1956; Qasim and Qayyum, 1961; Chaudhri, 1962; Chitray, 1965; Agrawal and Tyagi, 1969, Sinha, 1972, 1975; Chatterji, 1974; Chatterji et al., 1977 and others). However, biology of Puntius sarana has not been thoroughly worked out. Therefore, an attempt has been made to investigate the growth and food of P. sarana from the river Yamuna.

DESCRIPTION OF THE RIVER YAMUNA ITS BIOLOGICAL CHARACTERISTIC FEATURES AND ITS FISHERY

River Yamuna is one of the major components of the Ganga river system, the largest river system in India. River Yamuna borders parts of the state of Punjab and Hariyana, and flows through the Union Territory of Delhi.

The Yamuna is about 1,000 km long and has its source at about 8 km north of the Yamunotri hot springs in the Himalalayas. It enters the Doon Valley below Kalsi and the plains in Saharanpur district in Uttar Pradesh. It continues to flow south ward through Delhi up to Mathura, from where it flows generally in south east till it meets the Ganga at Allahabad. The Yamuna differs from the Ganga in various physical characteristic. The Yamuna is deeper and retains several times more water than the Ganga. The former spreads about 0.8 km to 1.6 km laterally during monsoon as against 3.2 to 4.8 km spread of the Ganga. The Yamuna shows a feeble current during summer but a fast one during monsoon with Ganga showing the reverse. The river Yamuna has a clayey bed and is rich in organic matter and aquatic vegetation.

Physio-chemical conditions of River Yamuna at Allahabad in relation to plankton concentration have been studied by Chakraborty _et al_. (1959) and Ray _et al_. (1966). Chakraborty _et al_. (1959) reported that the phosphates rather than the nitric seemed to have a more significant inverse relationship with phytoplankton. The maximum density of phytoplankton was 619 units and of zooplankton 189 units per litre in June, the lowest number of phytoplankton and zooplankton being 19 and 9 units per litre respectively in October. The ratio of zooplankton to phytoplankton was found to be 1:3. The bottom fauna of River Yamuna was studied at two centre, Sujawan and Minto Park Ghat about 19.2 km and 3.2 km upstream of the confluence with Ganga at Allahabad. (Ray *et al* ., 1966). Chironomid larvae, molluscs and annelide worms dominated at Sujawan, while at Minto Park chironomid larvae and amphipods were the main constituents.

Studies on the fauna inhabiting river vegetation were conducted during 1958-59 at two centres, viz Sujawan and Minto Park on River Yamuna . Molluscs and insects formed the major component of fauna at Sujawan, while insects mainly and, to a lesser extent, mulluscs and decapods dominated at Minto Park. The population was found to be maximum during March to May, and minimum during the monsoon. *Corixa* and *Hyphoporous* among insects, *Viviparous bengalensis*, *Succinea gravelyi*, *Melanie tuberculate* and *Gyraulus* sp. among mulluscs, and *Palasmon lamarrei* among decapods were the dominat forms.

The fishery which consists of various species of fish, namely. Major carps - *Labeo rohita*, *Cirrhinus mrigala*, *Catla catla*, and *Labeo calbasu*, minor carps - *Labeo bata*, *Labeo gonius*, *Puntius sarana*, Catfishes - *Mystus aor* and *M. seenghala* and *Wallago attu* Clupeide- *Hilsa ilisa* (only sporadic catches) and other fishes, including a number of miscellaneous species, such as *Pangasius pangasius*, *Silonia silondia*, *Notpterus chitele* *Eutropiichthys vacha* , *Septipinna phasa*, *Gudusia chapra*, *Rita rita*, *Aspidoparia morar*, *Cirrhinus reba*, *Ailia coila*, *Bagarius*

bagarius, etc. The prawns included *Macrobrochium malcolmsonii* and *Palaemon lamerrei*. Other species of fish are also found but they are not so commercially important.

TAXONOMIC POSITION AND GENERAL CHARACTERS OF *Puntius sarana* (Ham.)

A- SYSTEMATIC POSITION

Phylum	...	Chordata
Sub-phylum	...	Vertibrata
Super class	...	Gnathosto mata
Class	...	Osteichthyes
Sub-class	...	Actinopterygii
Order	...	Cypriniformes
Division	...	Cyprini
Family	...	Cyprinidae
Sub-family	...	Cyprinini
Genus	...	*Puntius*
Species	...	*Puntius sarana*

B- TAXONOMIC CHARACTERS

Taxonomic characters of some fish were examined throughly. These are as follows:

Commonly known as Putti in Aligarh.

1. Profile of head back elevated.
2. No pores on the snout.
3. Interorbital space convex and lower labial fold interrupted.

4. Length of the head 5 to $5\frac{1}{4}$, height of the body $3\frac{1}{3}$ to $3\frac{5}{8}$ in the total length.

5. Diameter of eye $4\frac{1}{4}$ to $4\frac{3}{4}$ in the length of head.

6. Lateral- line is complete.

7. Found in rivers and lakes throughout India.

8. Breeds once a year.

9. It may grow more than 1 foot in length.

10. Colours - When the fish is fresh there are sometimes horizontal bands along the rows of scales in upper half of the body.

11. Fins are whitish or yellowish while and externally stained with grey.

AIMS AND SCOPE OF THE PRESENT STUDIES

The *Puntus sarana* is a minor carp. It is intended to study the age, growth, scale length (radius) body length relationship, food and feeding habits of this fish from the river Yamuna in north India. The age determination of the fish provides an understanding towards the composition of the fish population with respect to age, age at maturity and possible life span. The growth studies lead to an assessment of the sustaining power of the stock in fishery while the application of length-weight relationship solves various problems concerned with the life history of fishes. Besides providing a mathematical relationship between length and weight of fish as a means of interconversion, such a relationship also yeilds information on the general well being of the fish, variations in growth, size at first maturity, gonad development and breeding season. The results so obtained may be useful for the management of the fisheries in the river. In this way we may help to implement the Government schemes to increase the fish production by utilisation of fresh waters for the culture of minor carps.

C H A P T E R - II

THE AGE AND GROWTH OF *Puntius sarana*

INTRODUCTION

No work has been undertaken on the age and growth of *P. sarana* except the observation on the length and weight relationship of this fish in Loni reservoir of Madhya Pradesh by Sinha (1972). The present work is an attempt to investigate the validity of scales as age and growth indicator, growth in length and weight at various ages, relationship between scale radius and body length, specific growth rate and length-weight relationship of *Puntius sarana* from the river Yamuna.

MATERIAL AND METHODS

The monthly samples of Puntius sarana for the present investigation were collected from the river Yamuna for a period of one year from September, 1979 to August, 1980. The collection was facilitated by fish contractors while most of them were bought from the fish market of Aligarh. The fishermen generally used gillnets of varying meshes and dragnets to catch the fish. The present investigation is based on monthly collection of 397 fish.

METHODS

The total length from the tip of snout upto the end of the caudal finray of lower half of the tail was measured for each seperately, by using the fish measuring board and all measurements were taken to nearest mm.

Each fish was weighed seperately along with guts and gonads intact on a balance sensitive upto 1.0 gm. Sex and maturity stages of gonads were determined by internal gross examination.

5 to 10 scales from each fish were picked up from just below the dorsal fin and above the lateral line uniformly and kept in well lobelled envelopes for each sex separately.

PREPARATION OF SCALE FOR EXAMINATION

The scales were thoroughly washed with water and scrubbed gently between the fingers to remove the mucous and extraneous matter attached to it. Then they were dried on blotting papers and kept in serially numbered envelopes.

In order to back - calculate the length of the fish at each annulus, all scales, used for observation were measured from the approximate centre of focii to the extreme right tip of the margin. The scales were placed on transparent graph paper and thus scale radii were measured directly. Transparent ruler scale was used for the same purpose.

The scales of P. garana attain fairly large size so they can be read without an optical aid. But most of the scales were read repeatedly with the help of binocular microscope, and the age values were recorded against each envelope.

Regenerated scales usually having fairly large focus were rejected. Accidental or damaged scales without even margin were also discarded.

Length attained at the time of formation of various annuli were back calculated for each fish separately using the following formula :

$$L_1 = \frac{S_1 \times L}{S} \qquad \text{(Lee, R.M. 1920)}$$

where,

L_1 = Length of the fish at time of formation of first annuli.

S_1 = Length from the focus to first annulus.

L = Total length of the fish.

S = Total length of scale.

Length attained by all the fish at various ages were back calculated. Relationship between total length and scale length of the fish was also established and discussed.

VALIDITY OF SCALES AS AGE AND GROWTH INDICATOR

The scales of Cirrhina mrigala, Catla catla and Labeo rohita showed clear zonation which could be used for studying the age and growth of these fishes (Jhingran, 1957, 1959; Natarajan and Jhingran, 1963; Kamal, 1969 and Khan and Siddiqui, 1973). These authors have also attempted to establish the annual nature of these rings and provided evidences in support of it. Puntius sarana is also a carp and its scales have also been found to bear clear annual rings. The accuracy of scale method for age determination of P. sarana was based on the following proportions as also pointed out by Van Oosten (1929):

1. That the scale must remain constant in number and must retain their identity throughout the life.

2. That the scales must bear a constant proportional relationship with the length of the fish. In another way it can also be summerised that the growth of the scale must be proportional to the growth of the fish.

3. That the annulus must be formed yearly and at the same approximate time of each year.

In P. sarana the number of scales along the lateral line were found to vary between 32-34 and within this range this number was highly constant. The size, shape and sculptural characteristic of the scales differed from one region to another but it almost remained constant throughout the life in one part and the highest degree of constancy in shape of the scales was found from the region just below the dorsal fin and above the lateral line.

It may be inferred that the scales of P. sarana are quite valid for age and growth studies of the fish. (see plate I II, III and IV)

Plate III.	Scale of the male fish showing annuli.	
	Age of the fish	- IV^{+}
	Total length	- 298 mm
	weight	- 330 gm

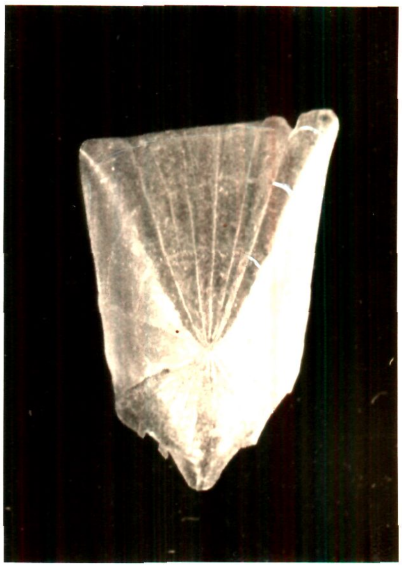
Plate IV	Scale of the females fish showing annuli	
	Age of the fish	- III^{+}
	Total length	- 250 mm
	Weight	- 260 gm.

Plate I. Scale of the male Fish showing annuli

Age of the fish	- VI^{+}
Total length	- 338 mm
weight	- 568 gm

Plate II. Scale of the female fish showing annuli.

Age of the fish	- V^{+}
Total length	- 328 mm
Weight	- 530 gm



BODY LENGTH AND SCALE LENGTH RELATIONSHIP

The validity of scale for growth studies depends upon the assumption that the size of the scale bears a constant relationship to the total length of the fish (Van Oosten, 1929; Whitney et al., 1956). It was also found that growth rate of scale decreases as fish becomes older, after first few years. In the present study Fig I(A) and (B) show a high degree of correlation between growth of the body and growth of the scale radius of both male and female fishes respectively. When the regression line of scale radius on total body length was drawn a straight line relationship was observed with a high degree of significance in both male and female fishes. The mathematical relationship between scale radius and body length can be expressed as :

$$Y = -1.600 + 0.0455\,X \quad \text{(Male fishes)}$$

$$Y = -1.800 + 0.0459\,X \quad \text{(Female fishes)}$$

Where Y is scale radius and X is total length of fish. The unit of their measurements is mm.

It is obvious from the equations that an increase in the length of the scale radius bears a constant relationship with the increase in the length of both male and female fishes.

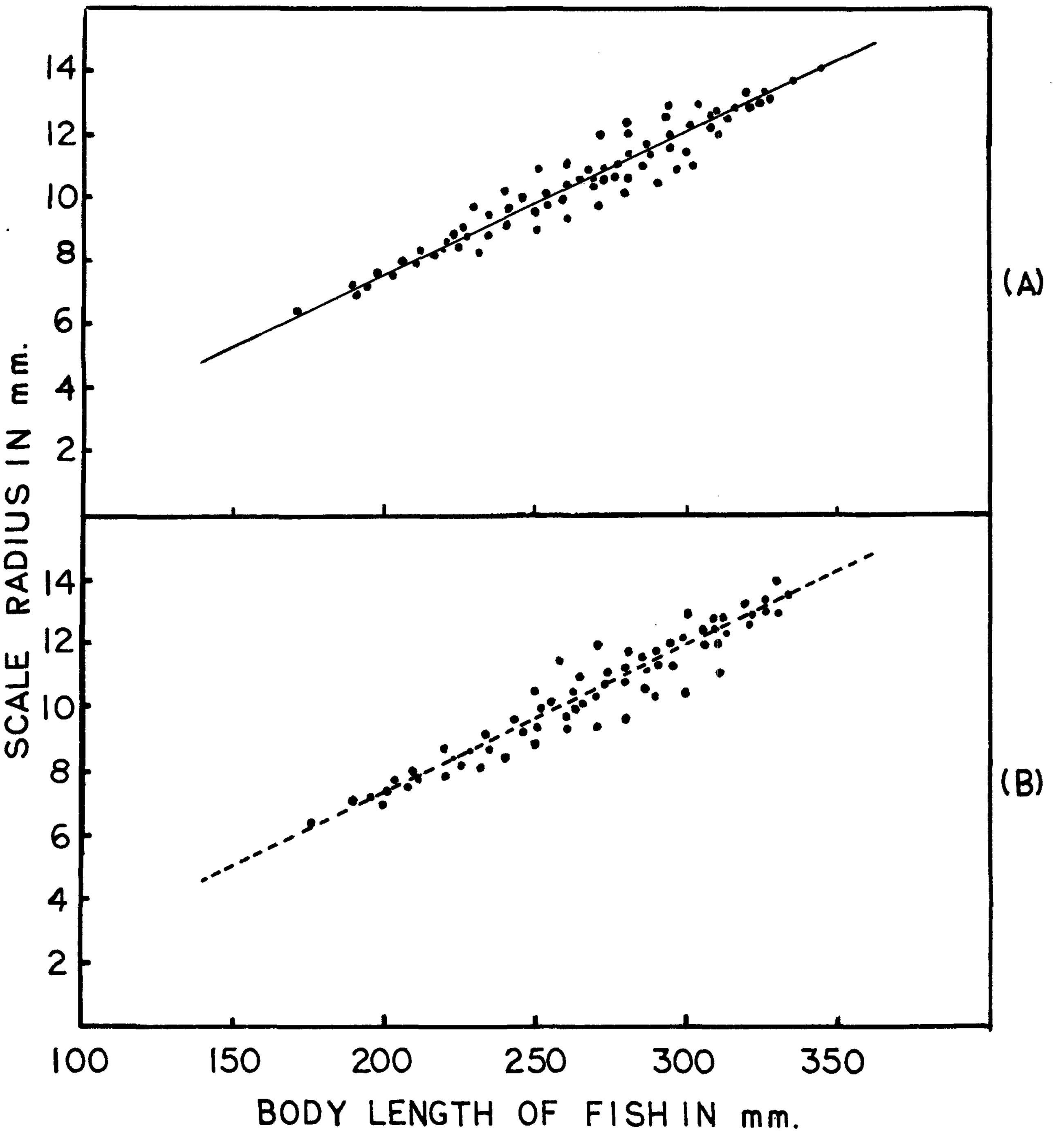


Fig I. The relationship between scale (radius) and body length of A- male B- female *Puntius sarana* of the river Yamuna.

ANNUAL GROWTH IN LENGTH

Fig. 2 based on table I. and II shows calculated mean length for age of P. sarana. The fish lengths have been found to vary between 112 mm and 344 mm for the fish from I to VI years of age. The male fish was found to attain the length of 120 mm. 185 mm, 240 mm, 235 mm, 320 mm and 340 mm at the age of I, II, III, IV, V and VI year respectively. While the female fish was found to attain the length of112 mm, 172 mm, 250 mm, 292 mm, 330 mm and 344 mm at the age of I, II, III, IV, V and VI year respectively. It is obvious from the fig. 2 that the male fishes show better growth in length upto second year of age but the female fishes show better growth thereafter. It may be because of the fact that the maturity in the males takes place a bit earlier than the females.

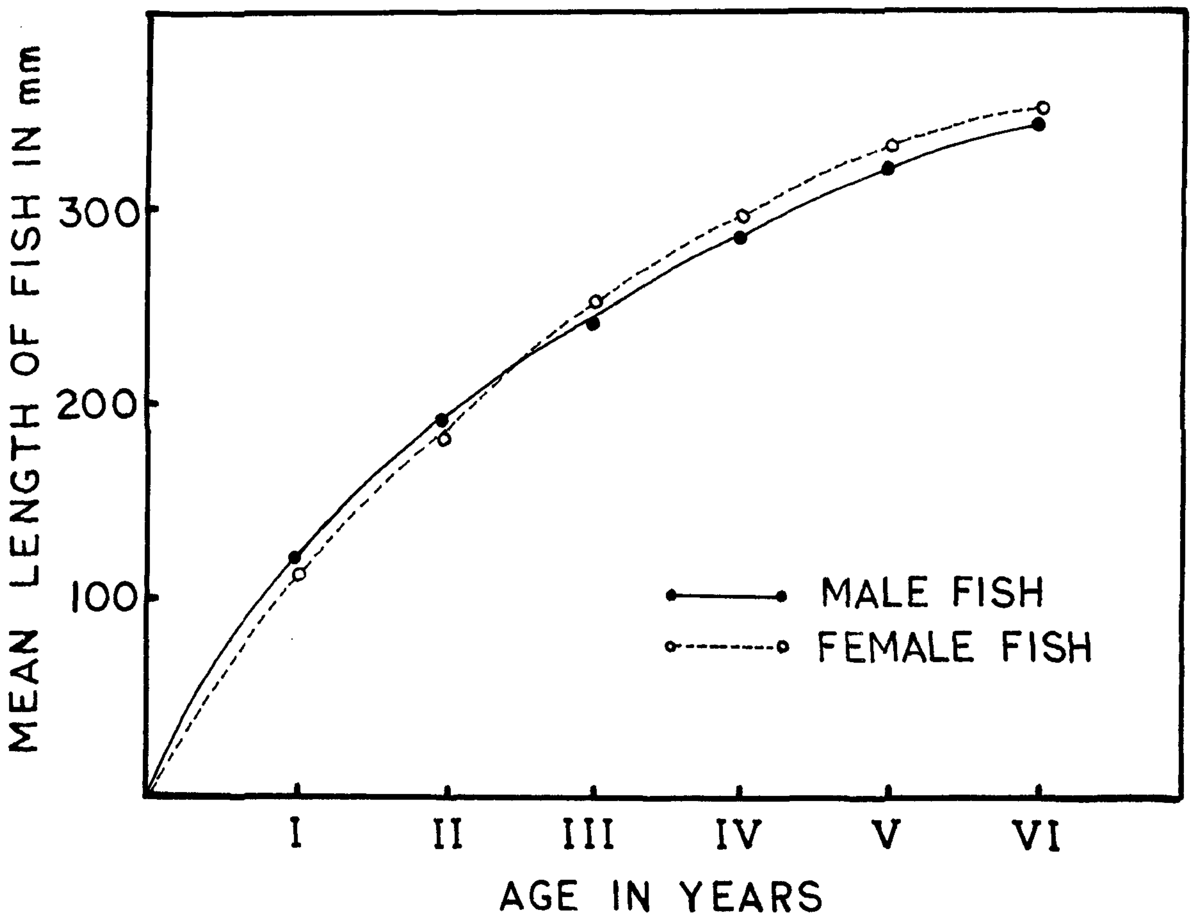


Fig 2. Calculated mean length for age of *Puntius garana* of the river Yamuna

ANNUAL GROWTH IN WEIGHT

Fig. 3 based on table III and IV shows the mean calculated weights of the fish for age. The mean weights for the male fish were 26 gm, 93 gm, 202 gm, 316 gm, 473 gm and 566 gm for I, II, III, IV, V and VI years of age respectively.

The mean weights for the female fish were 19 gm, 74 gm, 243 gm, 400 gm, 592 gm and 676 gm for I, II, III, IV, V and VI years of age respectively. It is obvious from Fig. 3 that the weight increases with the age of the fish. It is also intresting to note that the males are found to be heavier than the females up to second year of age and the females are found to be heavier than the males after second year onward. It may be because of the fact that the physiological changes take place in their respective gonads after second year of age.

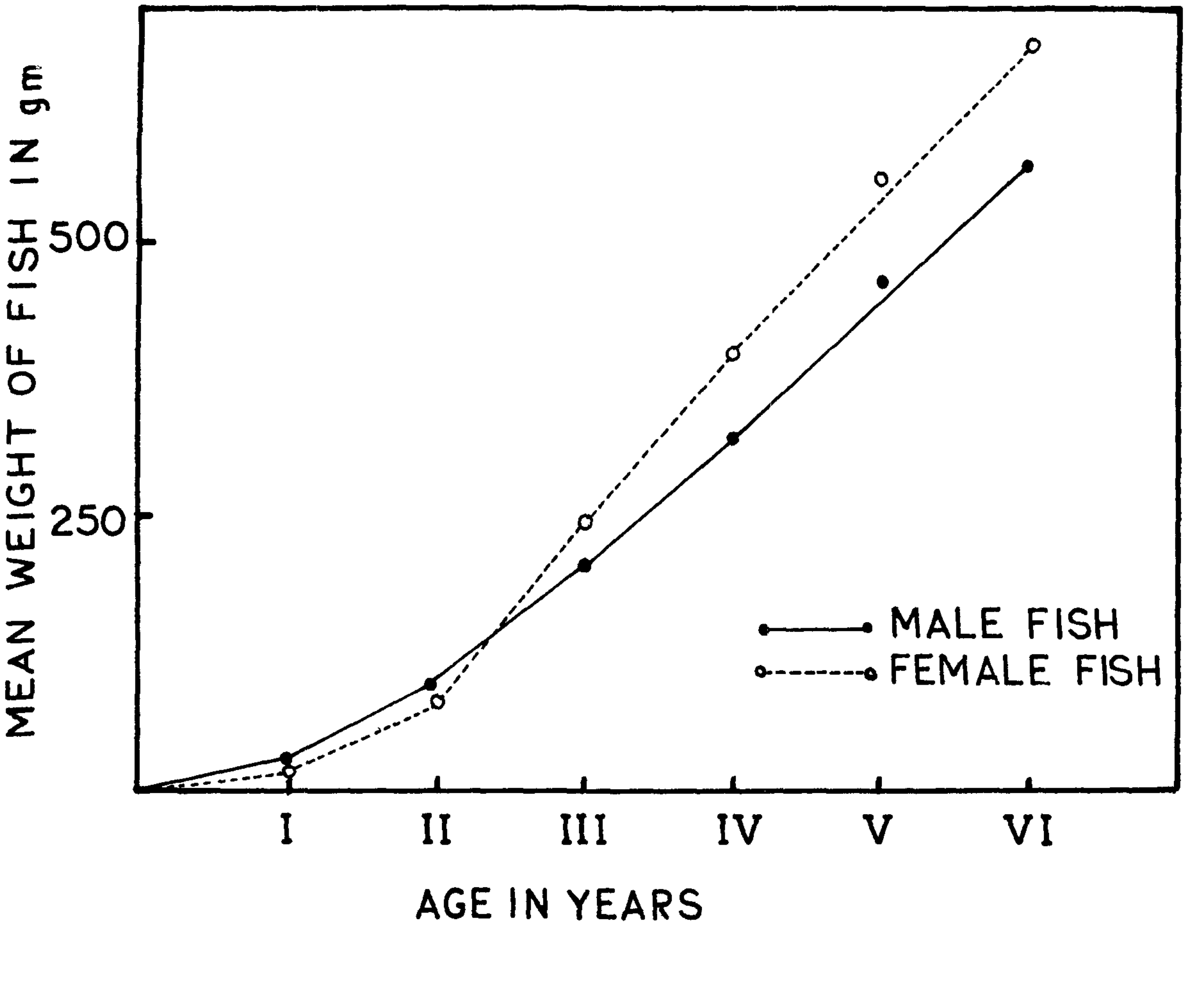


Fig 3. Mean weights for various age groups of *Puntius sarana* of the river Yamuna.

SPECIFIC GROWTH RATE

The specific growth rate of the fish has been calculated using the following formula given by Ball and Jones (1960).

$$\text{Specific Growth Rate (G)} = \frac{\text{Log e } L_2 - \text{Log e } L_1}{T_2 - T_1} \times 100$$

Where,

L_1 and L_2 are length at the end of year T_1, T_2

T_1 and T_2 is time at which fish attain length L_1 and L_2.

G is percentage specific growth rate per annum.

Fig. 4 shows specific growth rate of male and female P. sarana of the river Yamuna. It may be seen that the resulting growth rate commenced at 67% between I and II year, dropped to 47% between the year II and III and 38% between III and IV year and then it dropped to 33% between the IV and V year and to 30% between V and VI years of age of the male fish. The specific growth rate of the female fish commenced at 71% between the age I and II, decreased to 48% between II and III year and 37% between years III and IV. It then dropped to 32% between IV and V year and to 30% between year and V and VI. It is clear from the fig. 4 that percentage specific growth rate decreases with the age of fish.

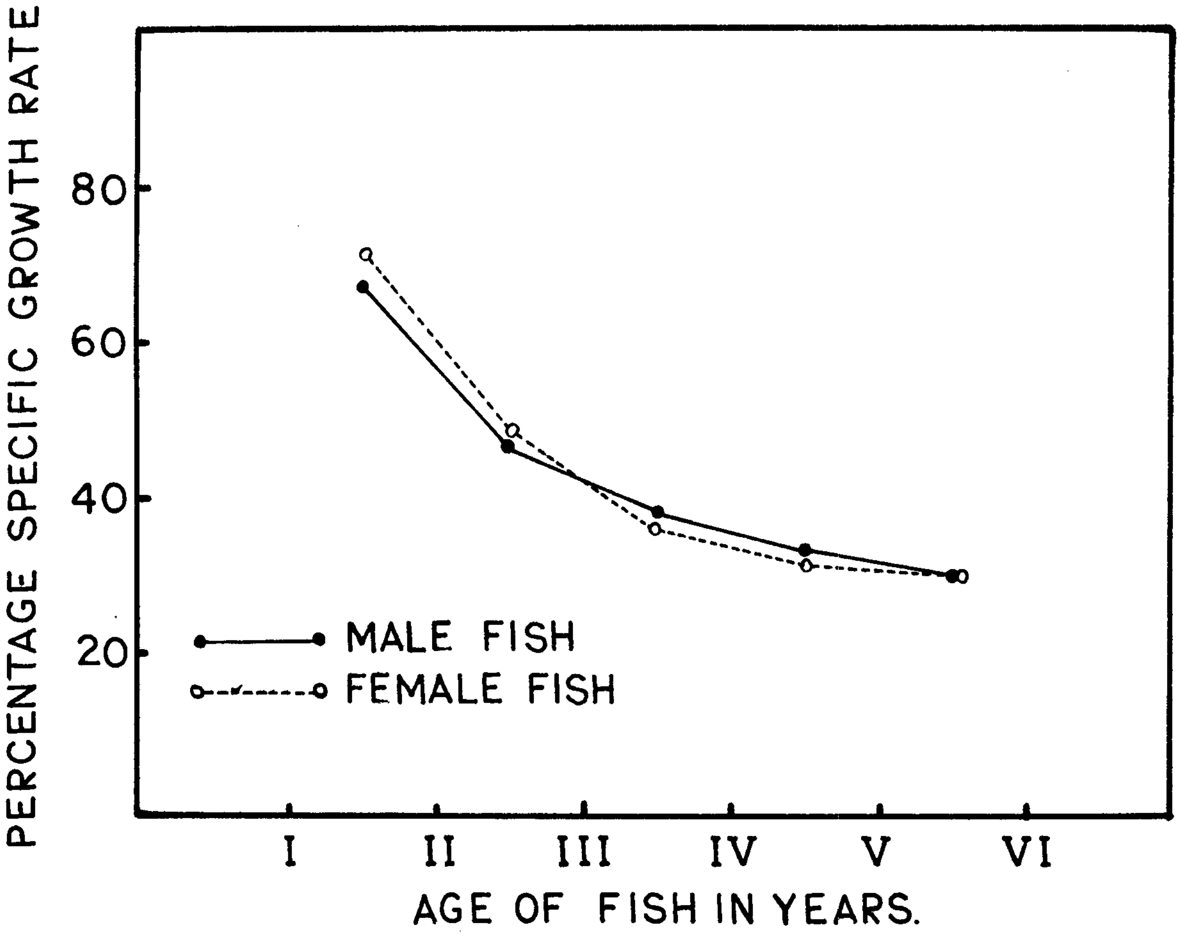


Fig 4. Changes in the specific growth rate with age for Puntius sarana of the river Yamuna.

However, the male and female fish show no significant difference in specific growth rate. Fig. 5 also reveals changes in specific growth rate with size of the fish. It can be said that the growth rate decreases with increasing size of fish in both sexes of the fish. It is, therefore, noted that specific growth rate (G) decreases with increasing age and size of the fish.

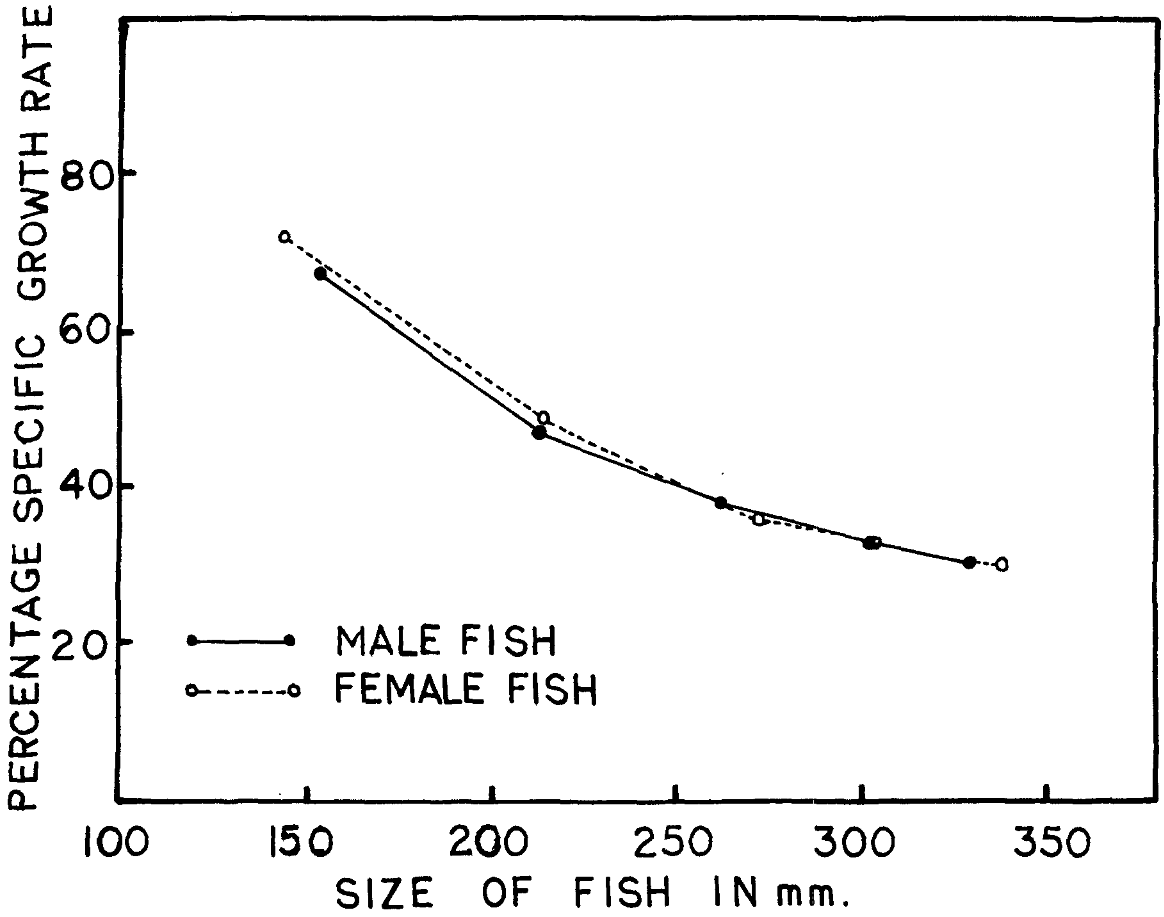


Fig. 5. Changes in specific growth rate with size for *Puntius sarana* of the river Yamuna.

LENGTH - WEIGHT RELATIONSHIP OF

P. sarana

The relationship between length and weight of fish has often been studied biologically. One principal approach has been to examine the length - weight relationship from the purely academic point of view of growth. The results of this method, if properly applied, do have practical value since they make it possible to convert length into weight and vice-versa. Another approach has been to yeild information on the general well- being of the fish, relative robustness, variations in growth, size at first maturity, gonad development and breeding season etc.

The relationship has been examined by the cube law.

$$W = C L^3$$

where 'W' and 'L' are weight and length respectively and 'C' is a constant. The assumption enolied in this law is that weight is a column function and length is linear and weight is roughly equal to the cube of the length. This law is further described as

$$W = a L^n$$

where 'W' is weight, 'L' is length and 'a' and 'n' are constants to be found empirically. Logarithmic equation has been found to be

$$\text{Log } W = \text{Log } a + n \text{ Log } L.$$

(Notations are same as above)

$$\text{Log } a = \frac{\Sigma \text{Log } W . \Sigma(\text{Log } L)^2 - \Sigma \text{Log } L . \Sigma(\text{Log } L . \text{Log } W)}{N . \Sigma(\text{Log } L)^2 - (\Sigma \text{Log } L)^2}$$

Where, W = weight

L = Length

N = Number of observations

Log is known as intercept.

Then

$$n = \frac{\Sigma \text{Log } W - N . \text{ Log } a}{\Sigma \text{Log } L}$$

'n' is known as slope.

The length and weight were two variables and a correlation figure 'r' known as 'correlation co-efficient' was prepared to discuss the relationship.

$$r = \frac{N \times \Sigma WL - \Sigma W \times \Sigma L}{N \times \Sigma W^2 - (\Sigma W)^2 \quad N \times \Sigma L^2 - (\Sigma L)^2}$$

Fig. 6 shows the length weight relationship of the male and female *P. sarana* from the river Yamuna. The smooth curve represents the calculated weight at mean length at an interval of one year while the straight line represents calculated regression line of the log weight on log length. The regression of the log weight on log length was calculated by least square method and separate equations for the male and female fishes have been found as :

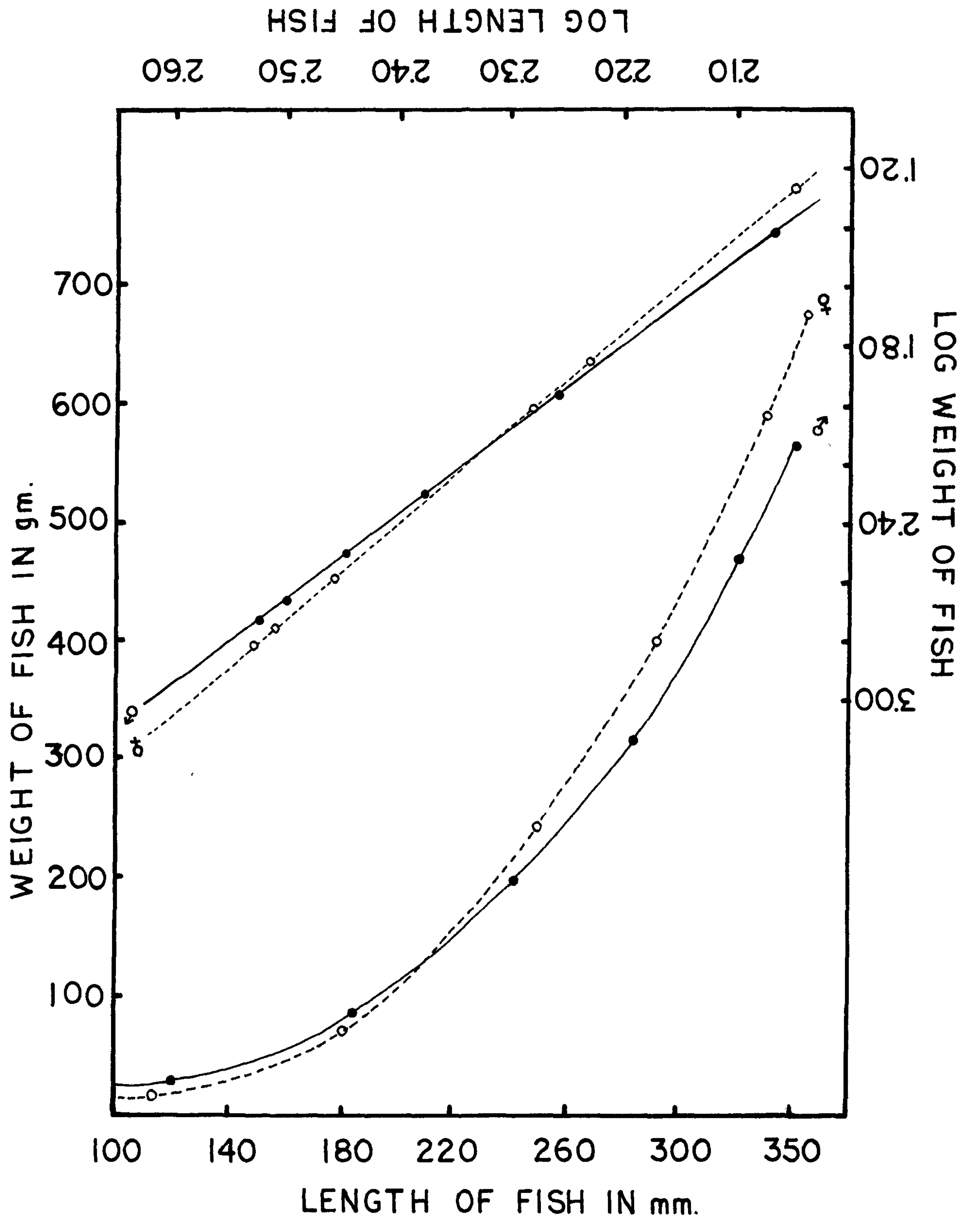


Fig 6. Length - weight relationship of _Puntius sarana_ of the river Yamuna.

$$\text{Log } W = -4.7363 + 2.9583 \text{ Log } L$$

Correlation coefficient 'r' = 0.9972 (Male fishes)

$$\text{Log } W = -5.2876 + 3.2002 \text{ Log } L$$

Correlation coefficient 'r' = 0.9680 (Female Fishes)

It is clear from the result that the values of the slope 'n' of the male fishes were slightly less than 3 i.e. 2.9583 hence the male fishes increased less than that of the cube of the length.

In the female fishes, the value of the slope and 'n' was 3.2002 i.e. more than 3 and hence the female fishes increased more than that of the cube of the length. Thus the length-weight relationship of P. sarana from the river Yamuna did not seem to follow cube law strictly but equilibrium constant showed certain variability around 3. Similarly values of the slope 'n' reported by Natarajan and Jhingran (1963), Jhingran (1957, 1959) and Chakrabarty and Singh (1963) in various species of Indian carps also did not follow the cube law strictly. Sinha (1972) undertook studies on length - weight relationship of P. sarana from Loni reservoir (M.P.). His observations do not strictly confirm to this cube law and equilibrium constant 'n' frequently show certain variability around 3.

It is also observed that the length - weight curve of males lies above the length - weight curve of females up to the length of 210 mm and beneath the length weight curve of female thereafter in P. sarana. The same phenomenon was found in L.bata of the river Kali (Chatterjee et al ., 1977). A reverse phenomenon in C. mrigala was found by Chakarbarty and Singh (1963). Thus in the present studies the males were found to be heavier than the females of their identical size in immature fishes while the female were found to be heavier than the male of their identical size in mature fishes.

Further it is observed that the length - weight curves of males and females fishes intersect at a point between 200 mm and 220 mm. This point of intersection represents the size at first maturity (Olsen and Merriman, 1946). The point of intersection between the length weight curves of the male and female Labeo bata was found to be between 250 - 270 mm in the river Kali. (Chatterjii et al ., 1977). In Catla catla the two curves intersected at a point between 500 mm and 650 mm at which most of the fishes attain maturity. The difference in the size of attaining maturity between minor and major carps are obviously because of slow and fast rate of growth.

DISCUSSION

The highest degree of constancy in the number, size, shape and sculptural characteristics of the scales in *Puntius sarana* have been found from the region just below the dorsal fin and above the lateral line. These scales could be used for studying age and growth of the fish. Generally the annulii on the scales of *P. sarana* were formed between June to August. Jhingran (1957, 1959), Kamal (1969) and Natarajan and Jhingran (1963) pointed out that the scales of *C. marigala* and *C. catla* showed clear annulation which could be used for studying age and growth of these fishes. These authors have also established the annual nature of these rings. The validity of the scale method for age and growth studies of *P. sarana* has been based on the proportion given by Van Oosten (1929). The scales of fish possessed certain carved out grooves like rings which were found to be annual in nature. Van Oosten (1929) stated that any cessation in the growth rate of the fish will result in the formation of check on the scale. This is mainly due to the following factors:

1. Environmental factor.
2. Physiological factor.
3. Genetic factor (Brown, 1946).

Generally it has been reported in temperate regions that the temperature is the main factor responsible for the formation of annual mark on the scales. A drop in the temperature during the winter is followed by a drop in metabolic rate which results in low intensity of feeding and consequently in growth rate of the fish slows down. During summer, the increase in temperature is followed by fast growth rate and wider scalerities (Cutler, 1919; Graham, 1929). Since the fluctuation temperature is cyclic and drop in temperature followed by check formation occur only once in a year, the rings are regarded as annual marks.

Brown (1946) observed that the annulus formation was mainly the result of an annual physiological cycle of change in the internal environment presumably the variation of secretion of an endocrine organ such as pituitary gland. Hickling (1933) attributed the formation of such zone (annulus) on the otolith of hake to a physiological rhythm, being laid down during the period of greatest physiological stress. The physiological stress in adult fishes is mostly caused by maturation and spawning . In majority of studies in temperate region, the emphasis has been given to temperature, but in seasonless tropic like India, where the fluctuation in temperature between the season is not as marked as in temperate regions, an annulus formation can not be attributed to temperature only.

The skeletal parts of tropical and sub tropical fishes also have growth checks similar to those found in temperate fishes (Menon, 1953; Seshappa and Bhimachar, 1954; Jhingran, 1957, 1959). Natarajan and Jhingran(1963) and Kamal (1969) suggested that due to absence of severe winter in tropical regions, a periodicity in growth of fishes is also not found and hence scales do not possess annual markings. These statements seem very surprising because in tropical waters also there is periodicity in physio-chemical and biological factors of water and there is also periodic rhythm in spawning. In presence of periodicity of these factors, it is not possible to accept that there is no periodicity in growth rate, while occurrence of annular rings on the skeletal parts of the tropical fishes has long been recognised.

Seshappa and Bhimachar (1954) while working on malabar sole reported that the scales of the fish show clear annual rings which are annuli. They suggested that such rings were formed under the influence of South - West monsoon, which resulted in depletion of food in bottom and this lack of food led to the starvation which was the main factor in the formation of the annual markings.

Thus the present study supports the view that even in tropical water, the annual rings are formed during and after monsoon month in the skeletal parts of the fish though the underlying factors are different from temperate region.

The mathematical relationship between body length and scale radius has shown a high degree of correlation. It has been found that the males show better growth upto second year of age while the females show better growth afterwards. This may be because of the fact that the male fishes mature a bit earlier than the female fishes. Hence the males grow faster than the females before they attain maturity. Similarly mean weights for age reveal that the males are slightly heavier than the females of their identical age upto second year of age and the females are heavier than the males of their identical age after second year of age. It is inferred that the physiological changes take place in their respective sexes after second year of age and the stress caused by attainment of sexual maturity was greater in the females than the males, resulting in slow growth of the females upto second year of age. The same phenomenon was reported in Cirrhina mrigala (Chakraborty and Singh , 1963).

It has been found that the specific growth rate 'G' of P. sarana decreases with increasing age and size of the fish. Ball and Jones (1960) while studying the biology of Llyn Tegid trout also found that specific growth rate of the trout decreased with increasing age and size.

Further it has been found that the fish do not seem to follow the cube law strictly for their length - weight relationship. A perusal of the length - weight equation derived for P. sarana of the river Yamuna indicate the values of 'n' equilibrium constant to be 2.9583 and 3.2002 for the male and female fishes respectively i.e. show variation around 3. Khumar (1978) observed the values of the slope 'n' to be 3.20 and 2.63 for P. sarana from the river Kali and the Keetham reservoir respectively. From the results obtained for P.sarana of the river Yamuna, it may be concluded that the female fishes increase more than the cube of the length while the male fishes grow less than the cube of the length. The female fishes showed enormous increase in weight of gonads during spawning season, hence caused the increase in the body weight. In other carps the higher values of 'n' than 3 have also been reported (Jhingran, 1952; Chakraborty and Singh,1963; Natarajan and Jhingran,1963; Bhatnagar, 1972; Khan, 1972, Ramamohan Rao and Hanumantha Rao, 1972; Chatterji et al., 1977).

C H A P T E R - III

THE FOOD AND FEEDING OF *Puntius sarana*

INTRODUCTION

Feeding is one of the important functions of an organism. The basic functions of an organism take place at the expense of the energy which enters the organism in the form of its food. All the other energy processes within the organism of the fish also proceed at the expense of the food, it clearly ensures that 'feeding is a life sustaining function.'

Very little information is available so far on the food and feeding of minor carps. A few observations on the food and feeding habit of P. sarana have been undertaken by a few scientists (Mookherjee et al., 1947; Chacko and Kuriyan, 1948; Das and Moitra, 1955; Moitra, 1956; Chitray, 1965; Agarwal and Tyagi, 1969 and Sinha, 1972). The present investigation was undertaken to get a clear picture of the food and feeding habit of P.sarana from the river Yamuna and attention was also devoted to the following aspects:

(i) The relationship between gut length and bodylength.

(ii) Annual food composition.

(iii) Stomach fullness Index and

(iv) Seasonal variation in food intake of the fish.

MATERIAL AND METHODS

The material for the present investigation was collected from the river Yamuna for a period of one year from September, 1979 to August, 1980. The collection was facitilated by fish contractor. This investigation is based on the total collection of 397 fish.

EXAMINATION OF THE FISH GUT

The total length and gut length of each fish were recorded to the nearest millimeter. The guts were removed and preserved in 5% formalin for detailed study. The intestinal contents were washed into a petridish for quantitive and qualitative analysis of food. The macro - organisms of food constituents of the fish were identified with the nacked eye and micro - organisms were identified with the help of a microscope. The rectal contents were also analysed to see the various items of undigested food items. Analysis of food was undertaken by the following methods.

1. Occurrence method.

II. Volume method.

These methods have been earlier adopted by Hynes (1950) and Siddiqui (1967).

The fullness of stomach with food items was recorded. Fullness of stomach was classified as very full, full, [illegible] full,

½ full, ¼ full, trace and empty and points were awarded for each category as 30, 20, 15, 10, 5, 1 and 0 respectively. The mean fullness index was calculated for each month.

The occurrence method is based on the food items present in each stomach. The items were listed and the result were expressed as a percentage frequency of occurrence. In volume method, the volume of each item was determined and expressed as percentage volume of various food items present in the gut.

The feeding variation in relation to the size of the fish was examined. The fish were delineated into two distinct size groups. One of the size group was represented by the fishes which were more than 200 mm in length and the other size group of the fishes was between 112 mm and 200 mm in total length. These two size groups have been termed as 'Large' and 'Small' fishes in the text.

RELATIONSHIP BETWEEN GUT - LENGTH AND BODY - LENGTH

The feeding adaptation of fishes is particularly evident in relative length of the gut. Das and Nath (1965) said that the ratio between gut length and body - length is less than or equal to unity in carnivore fish where as in herbivore and omnivore it is more than unity.

Fig. 7(a) and 7(b) show a straight line relationship between gut - length and body - length. It is clear that the gut length increases with the size of the fish. There was a variation in the ratio betwaen the two size groups of the fish. The ratio was 1: 1.34 and 1: 1.63 for small and large fish respectively. The mean ratio for the combined fishes was 1:1.54 showing an omnivorous feeding adaptation.

ANNUAL FOOD COMPOSITION

Molluscs, macro - vegetation, plankton and insect were found to be important items in the food of P. sarana from the river Yamuna. However, the intensity of the food consumption varied with the size of the fish.

Fig. 8(a) and 8(b) based on table VI (a) and VI(b) show food composition of the fish of two size groups. The detail of each food item is as follows:

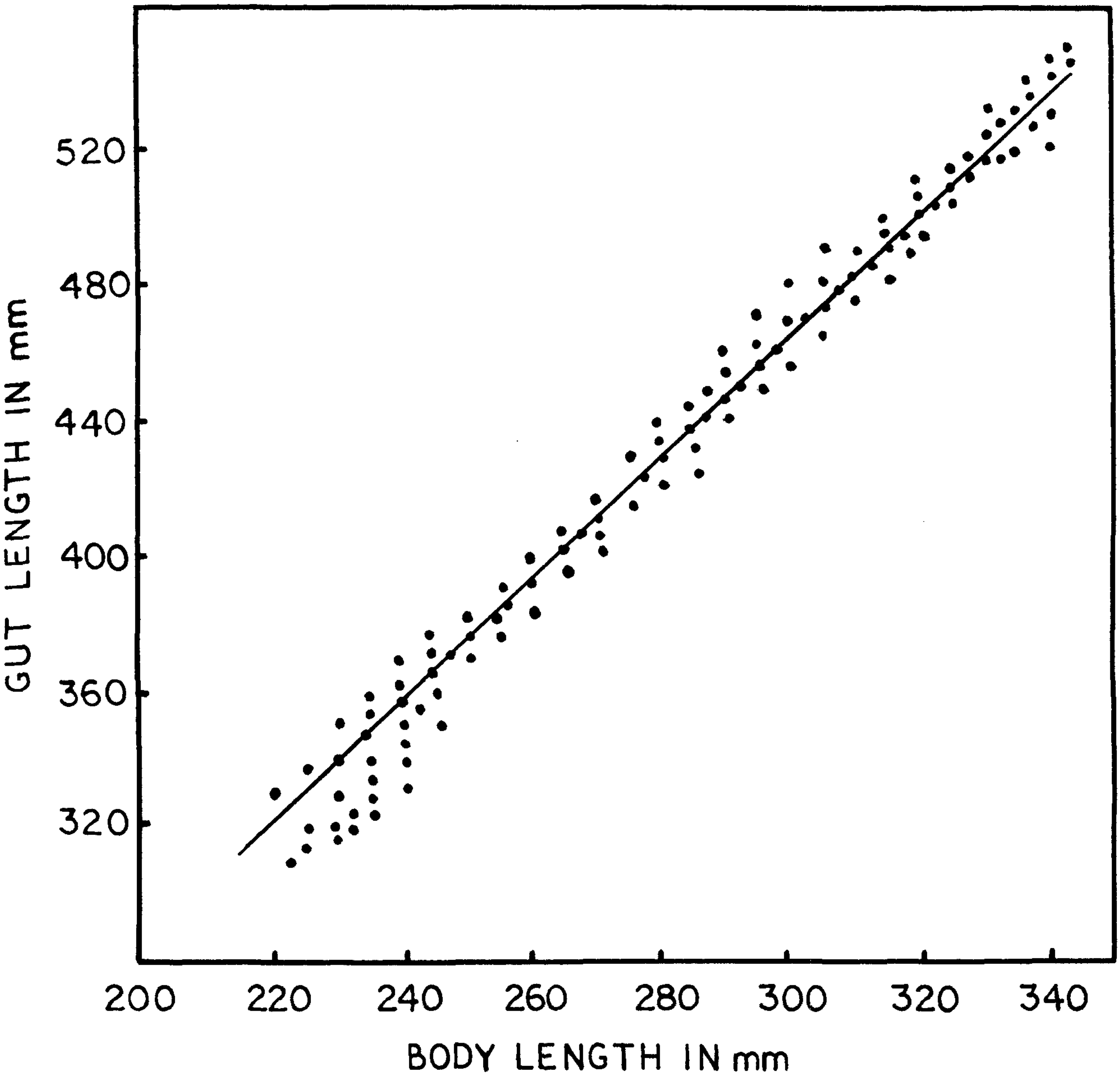


Fig 7(a). Body length - gut length relationship of *Puntius sarana* of large size (201 mm - 344 mm)

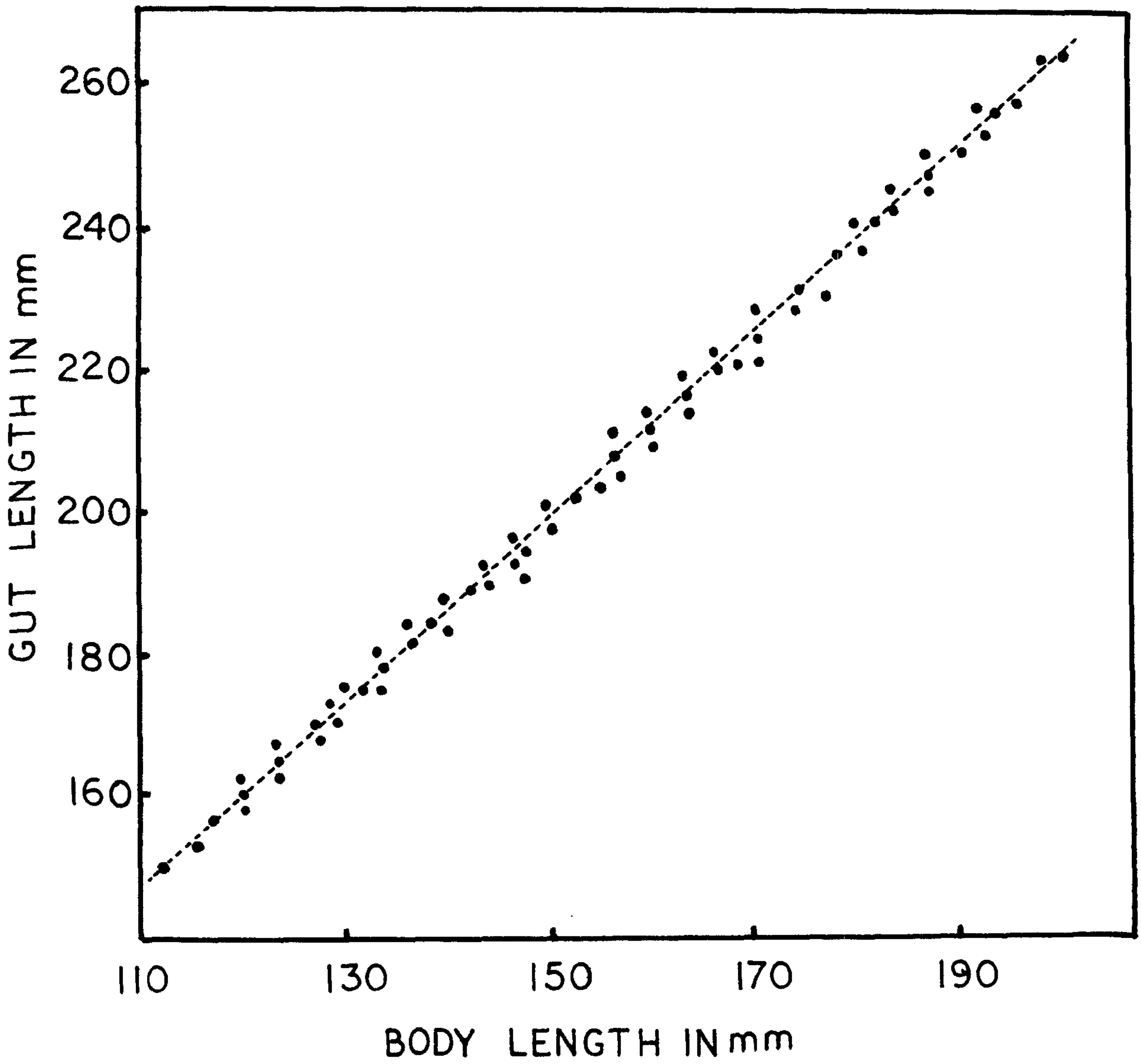


Fig 7(b). Body length - gut length relationship of *Puntius sarana* of the small size (112 mm-200 mm)

MOLLUSCS:

Gastropod was the most popular diet of the fish. The large fish consumed more gastropods than that of the small fish. The molluscs shells were not fully digested in the gut and passed out as broken parts. Various forms of Gastropoda and pelecypoda were recognised in its food content. The main genera were Viviparous, Indoplanorpis, Gyrarurus, Planorbis, Piscidium and parreysia. The bulk of the fish diet was mainly represented by Viviparous, Indoplanorbis, Gyrarurus and Planorbis.

MACRO - VEGETATION:

This was the most popular food item of the fish forming 24% and 45% of the total food for small and large fish respectively. Roots, stems, leaves and weeds were seen in its diet. Even cereals like barley, gram and wheat which may be undigested cereals in the cow dung discharged around the river banks, were also found in the gut of the fish. Hydrilla and Spirodela were the abundant macro - vegetation which formed the common diet of the fish. Rectal contents also showed the presence of undigested and partially digested Hydrilla and Spirodela. The frequency of occurrence of macro- vegetation was 20% and 30% of the food for the large and small fish respectively.

PLANKTON:

Planktonic diet of the fish was mostly dominated with

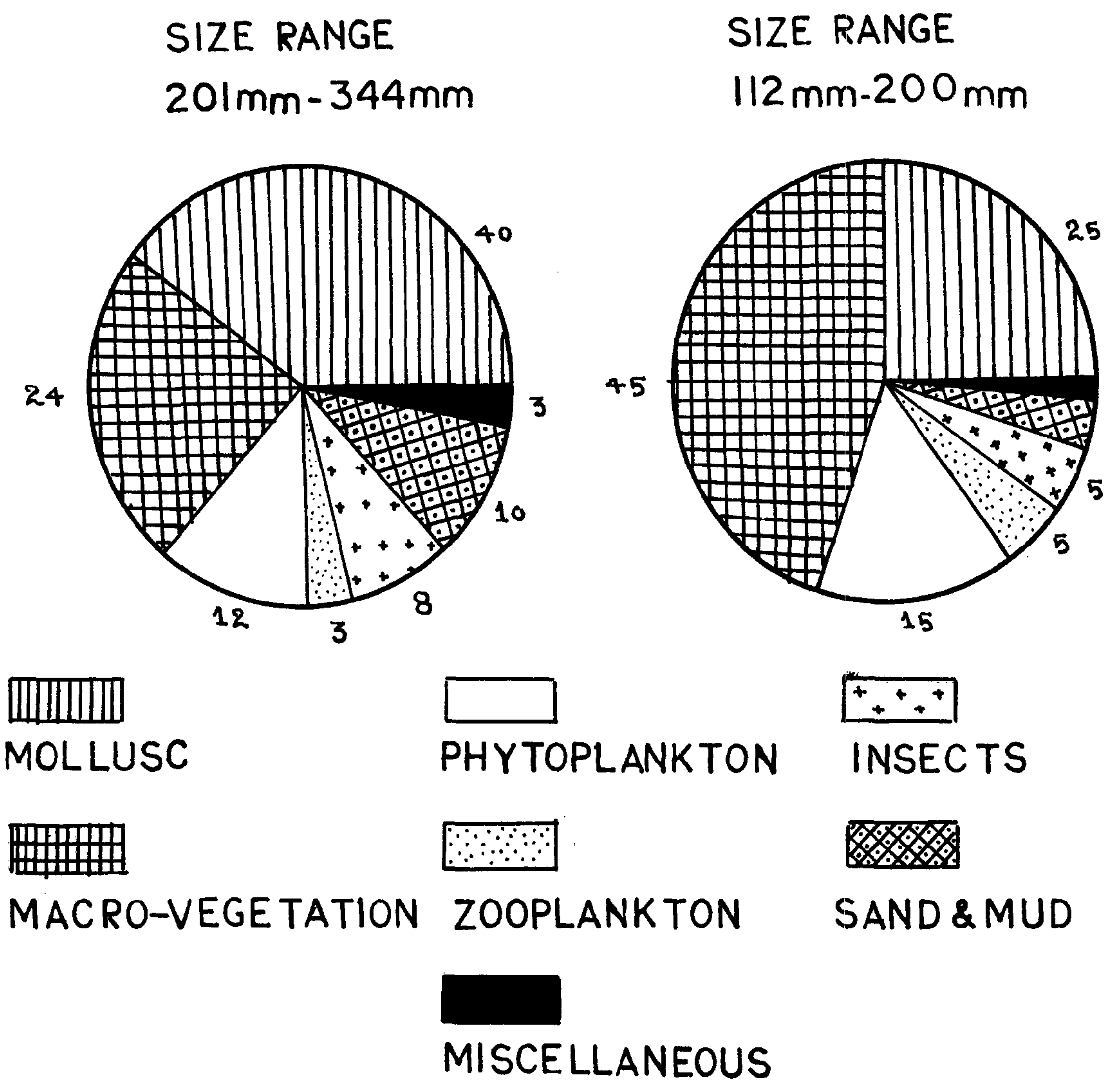


Fig 8(a) Annual food composition (by volume) of *Puntius sarana* of the two size groups.

phytoplankton forming 12% and 15% of the total food intake in the large and small fish respectively. The phytoplankton were represented by the following genera of three families.

1. Cholorophyceae: Spirogyra, Ulothrix, Oedogonium, Cosmarium, Microspora, Zygnema and Cladophora.

2. Bicillario-phyceae : Gyrosigma, Synedra, Gamphonema and Navicula.

3. Myxophyceae : Oscillaloria and Merismopedia

The bulk of the phytoplanktonic diet of the fish was found to be dominated by Spirogyra, Ulothrix and Oedogonium of the Chlorophyceae family while the mebbers of Bacillario-phyceae family were moderate and those of Myxophyceae family were rarely seen.

Zooplankton were mainly represented by a few genera of protozoans i.e. Volvox, Eugiena, Phacus etc. in the diet of the fish. Zooplankton were not a significant diet of the fish as the frequency of their occurrence was 7% of the total food intake.

INSECTS:

Insects were represented by Trichopteran and Dipteran larval forms in the diet of the fish. Generic identification

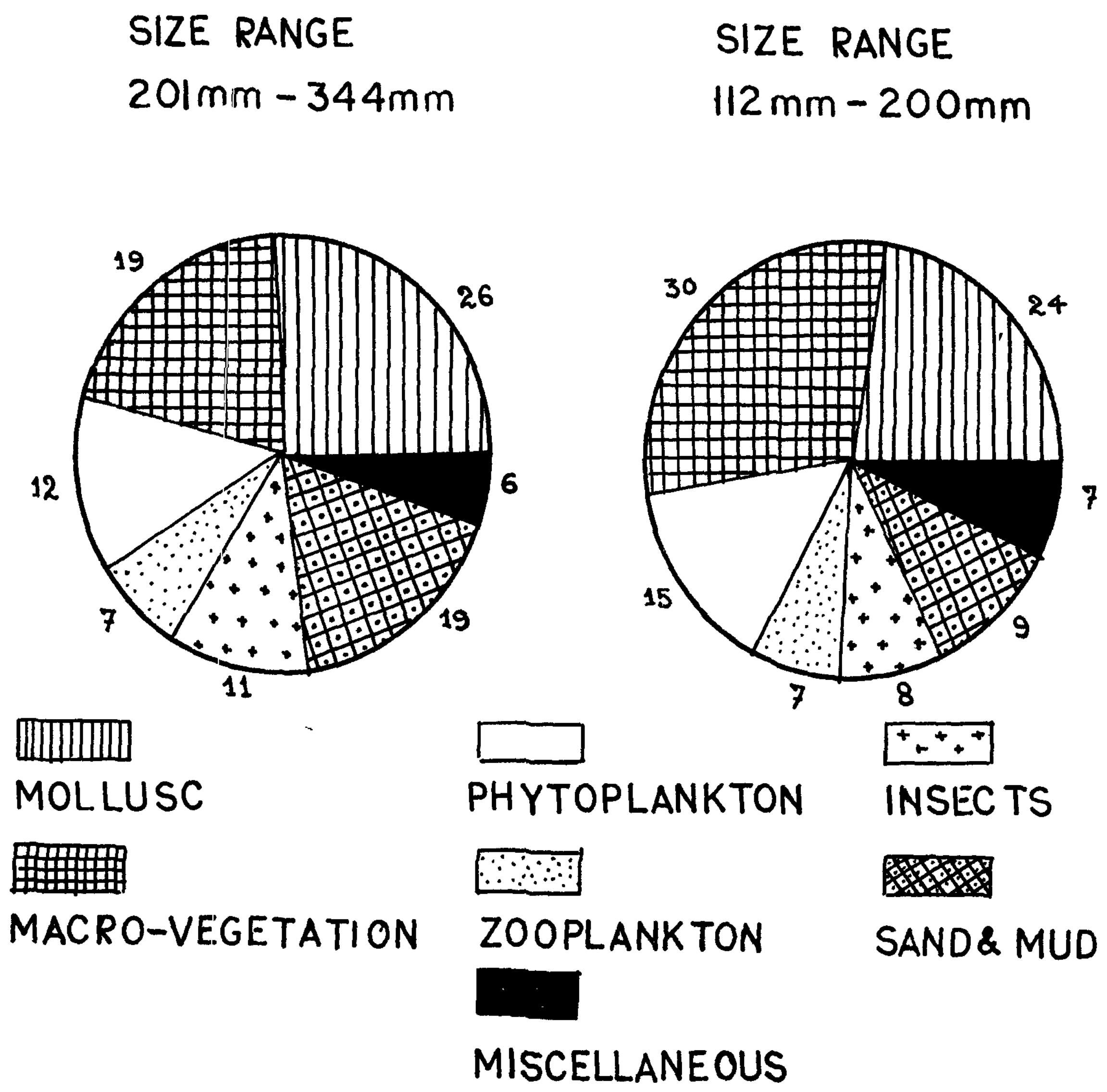


Fig 8(b). Annual food composition (by occurrence) of *Puntius sarana* of the two size groups.

was not possible because of its always being semidigested. Insect eggs and larvae (Chironomus) were often found in the diet of the fish. The frequency of occurrence of insect larvae in the fish stomach was 11% and 8% in the large and small fish respectively.

MISCELLANEOUS:

At times fish was found to consume fish scales, bones and pieces of wood which may have been ingested alongwith bottom organisms of the river. Debris and stones appear to have also been ingusted while the fish was grazing on the bottom organisms of the river.

STOMACH FULLNESS INDEX

Fig. 9 based on table VII shows certain variability in feeding intensity of the fish during September, 1979 to August, 1980. The maximum feeding activity of the fish was noticed in January. There was a gradual drop in feeding intensity from January onwards with its minimum in June. The subdued feeding extended upto September after which it again showed rising trend.

There was a marked variation in the feeding intensity of the mature fish between the pre and post spawning season. The spawning period of P. sarana extends from April to early September. During these months low feeding activity of the fish was observed. But after spawning the fish showed an active feeding trend. The immature fish also showed variation in feeding activity during winter and summer. High temparature and low dissolved oxygen concentration in the ecosystem may adversely affect the metabolism of the fish in the summer months and consequently feeding activity is affected.

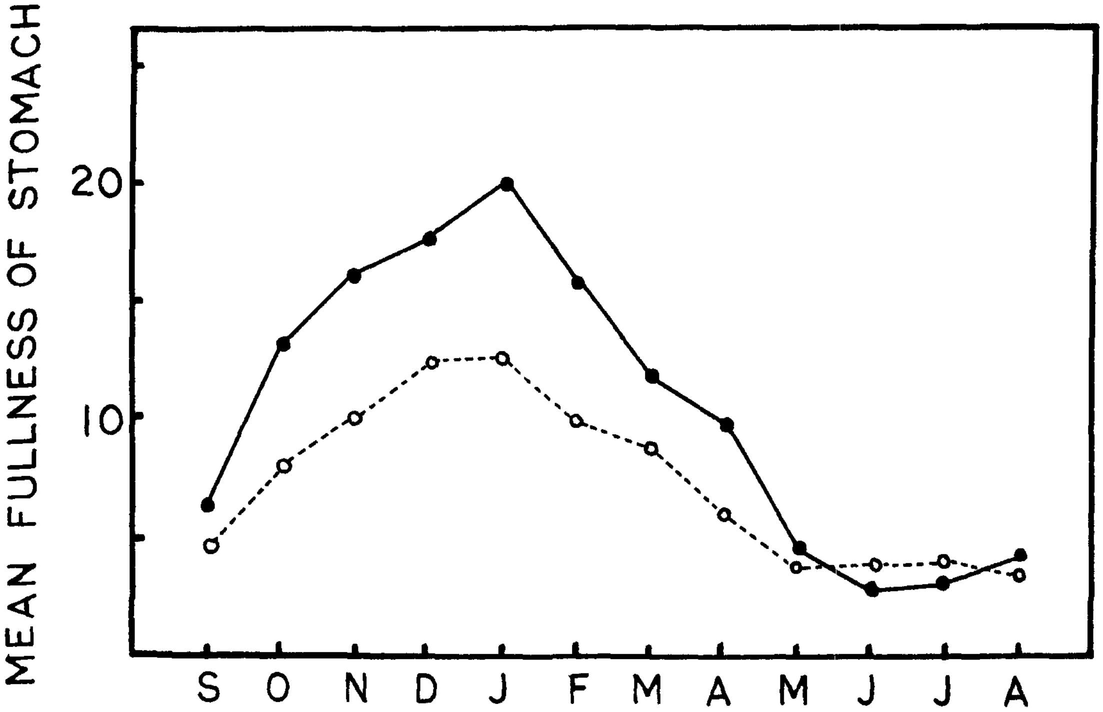


Fig 9. Monthly variation in fullness index of stomach of Puntius sarana.

SIZE RANGE

●——● 201mm - 344mm ; o-----o 112mm-200mm

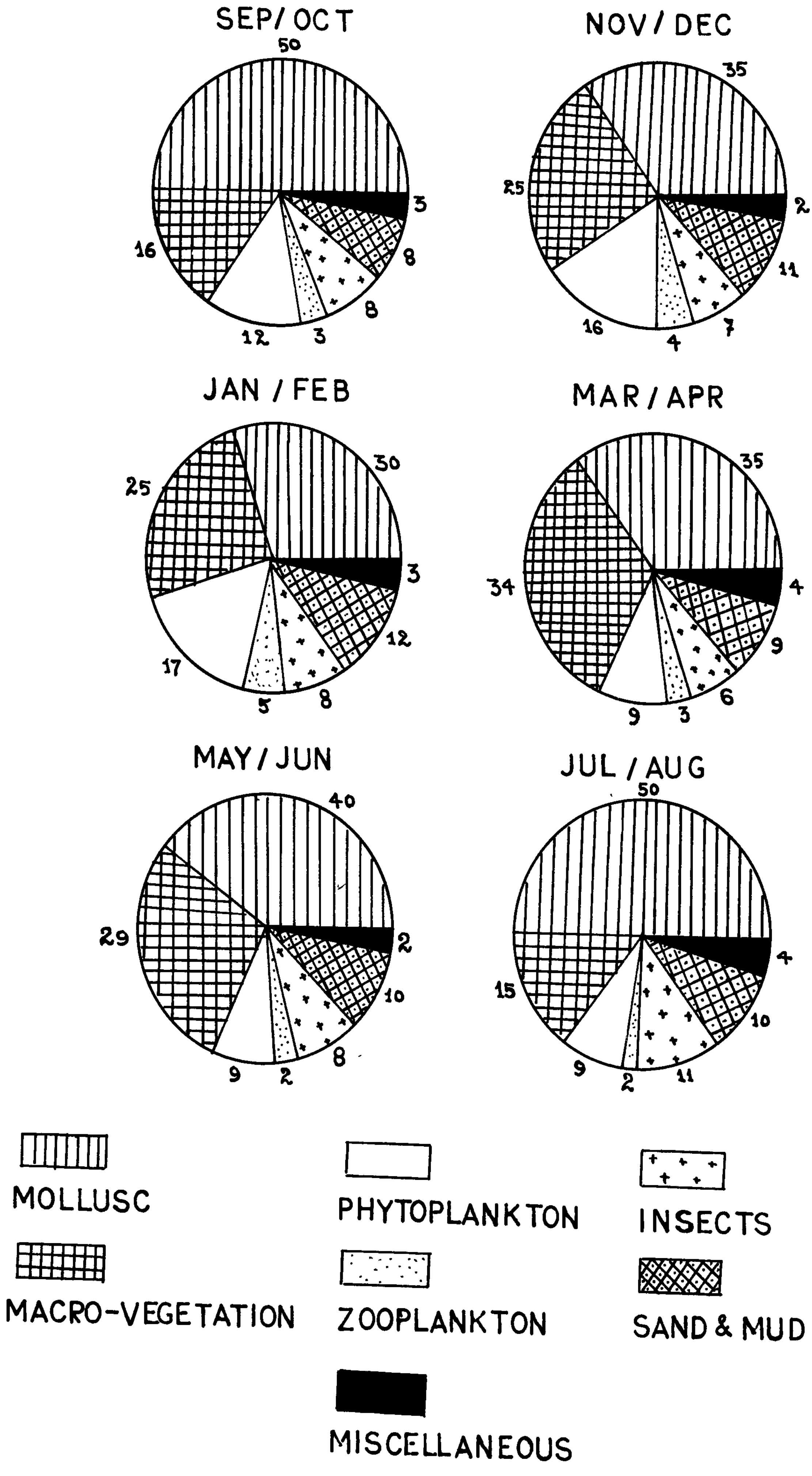
SEASONAL VARIATION IN THE FOOD INTAKE

Figs. 10(a) and 10(b) based on tables VIII (a) and VIII (b) show seasonal variation in the food composition (by volume) of P. sarana . Similarly Figs. 11(a) and 11(b) based on tables IX (a) and IX (b) show seasonal variation in the food composition (by occurrence) of the fish. The results obtained by these two methods show a great agreement.

Molluscs have been eaten in large quantities by the fish in rainy season. However, mollusc consumption was moderate in the winter and the summer months. The seasonal variation in molluscs intake of the fish may be related with the seasonal variation in the relative abundance of the mullusc which breed in rainy season. Hence, new recruitment of various species of mollusc take place in Monsoon months.

Macro - vegetation was consumed in large quantities in the summer. However, there was an obvious variation in the intensity of macro- vegetation intake between the small and the large fish. Macro - vegetation was more popular in small fish than that of the large fish in the summer months.

Apparently there is a little seasonal variation in plankton consumption of the fish. The fish seem to consume more planktons in the autumn and winter season than that of other seasons. Moreover the intensity of phytoplankton intake is more through-out the year than that of the zooplankton. It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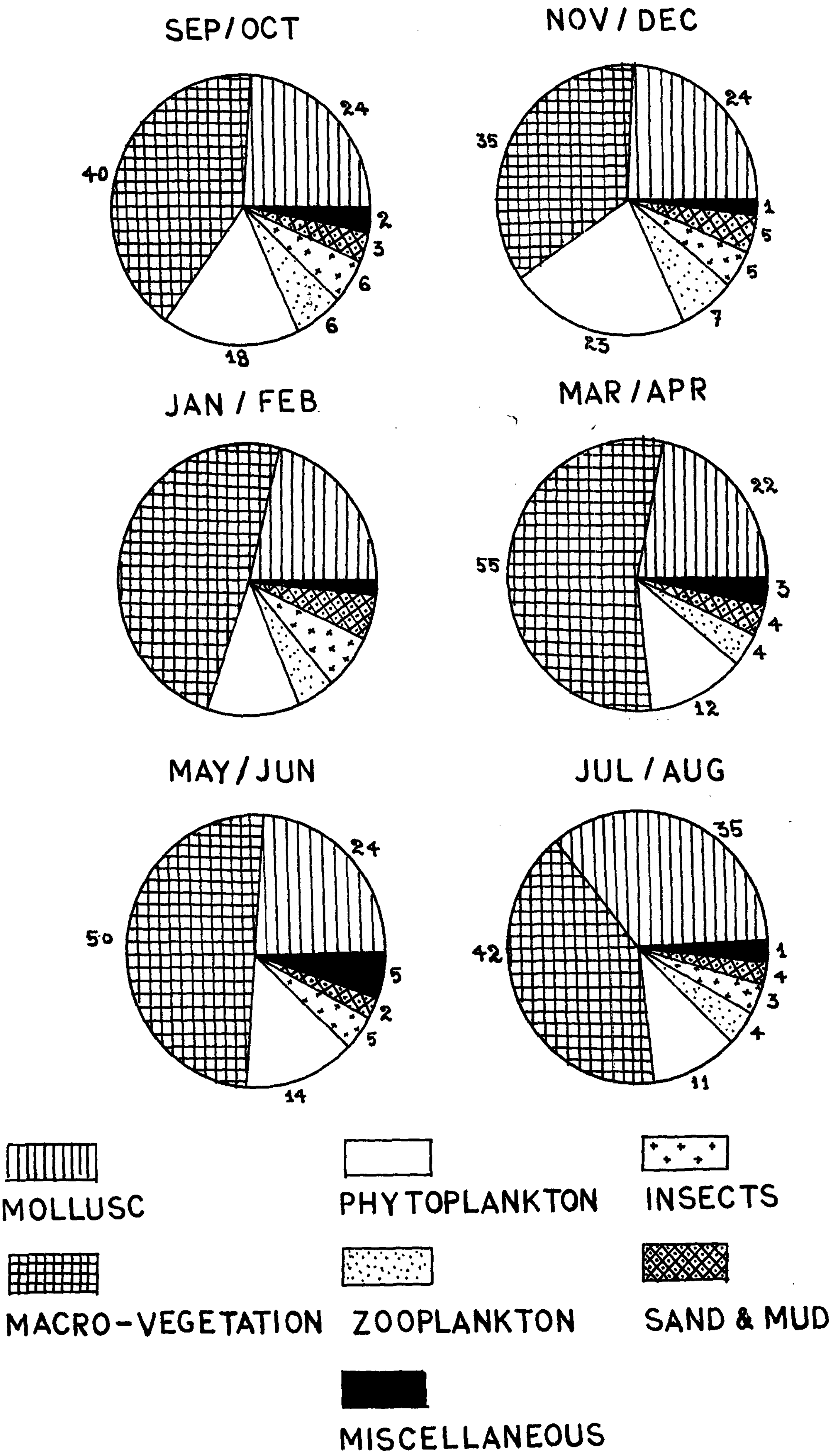
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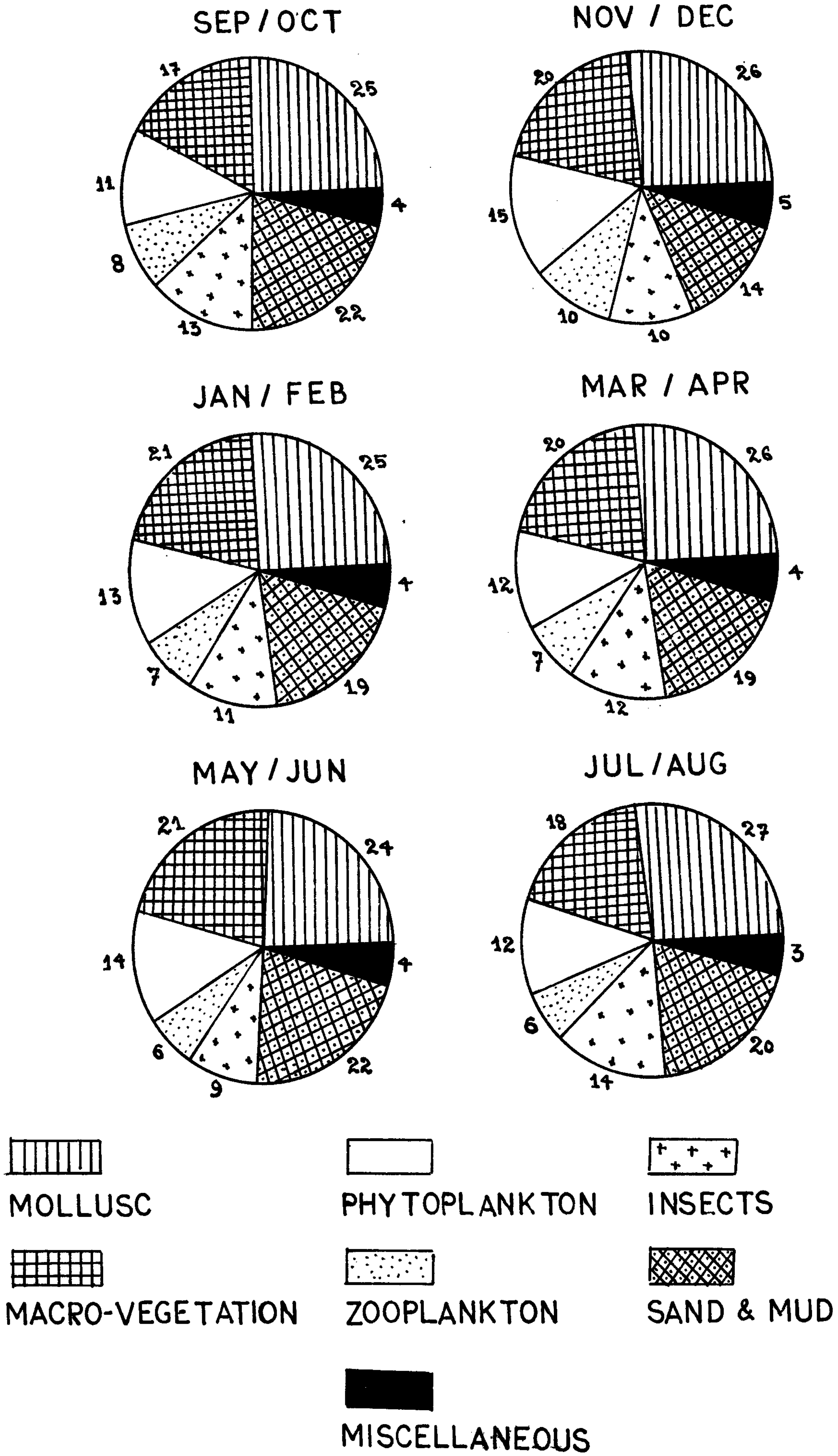
MISCELLANEOUS

may be relevent to mention that the small fish did not feed on zooplankton during the summer months (May - June). High temperature during this season may have prevented the fish to come over the surface of the water to feed on the zooplankton.

The seasonal variation in the food intake of the fish appears to be related with relative abundance of the food organisms in the river.

Fig 11(a)

Bimonthly food spectrum of *Puntius sarana* of the river Yamuna by occurrence of the large size group (201mm.-344mm)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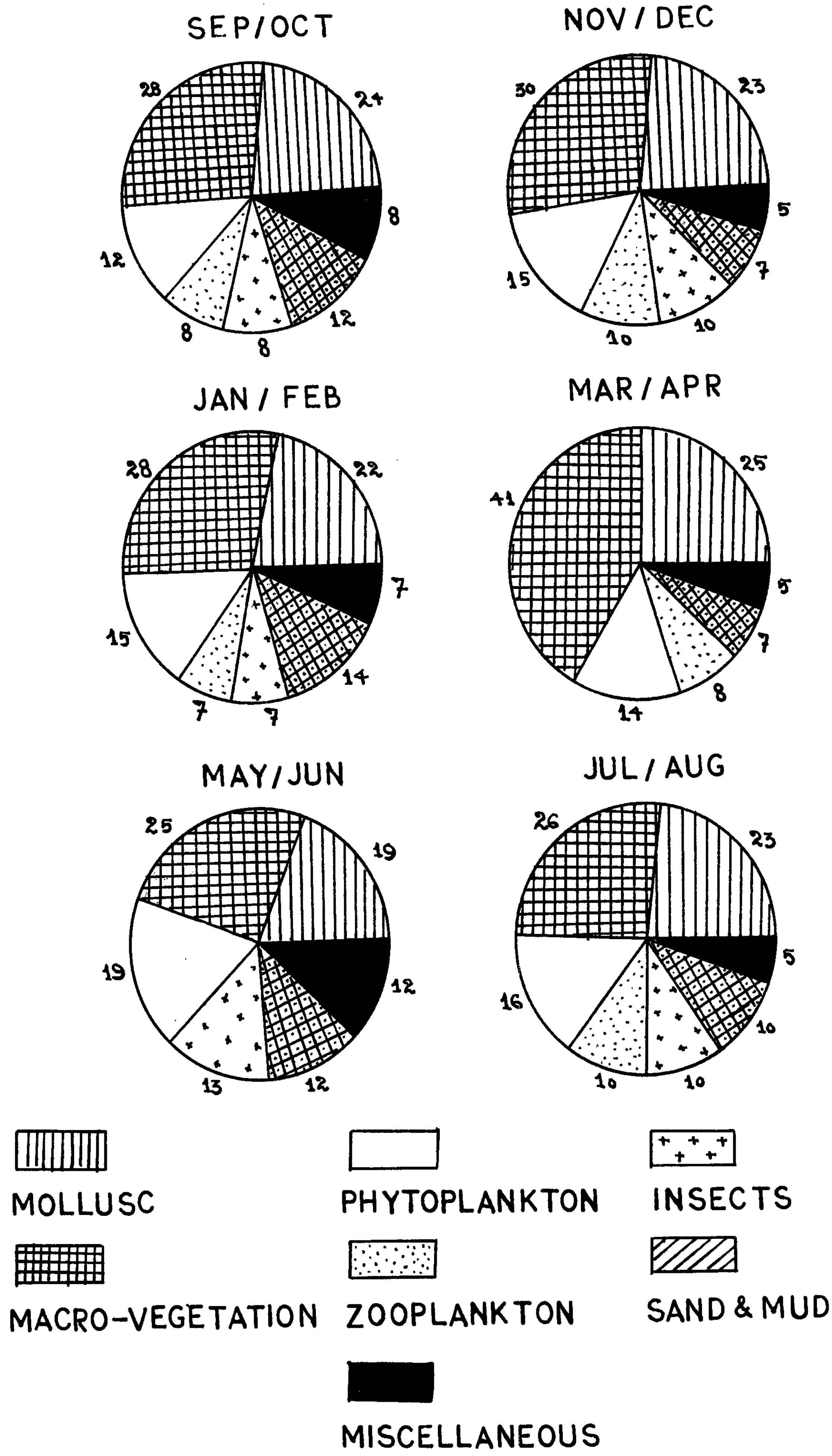
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DISCUSSION

It has been found that the *Puntius sarana* of the river Yamuna was omnivorous in habit. The gut - length and body - length relationship of the fish also reflected the omnivorous adaptation of the fish. The main diet of *P. sarana* consists of mulluscs, macro - vegetation, plankton and insect. Other dietary items like chronomid larvae, insect eggs, fish scales, bones, pieces of wood, sand and mud were of secondary importance as they were occasionally consumed.

Regarding the diet of this fish, diverse opinions have been expressed in the past in different regions. Mookherjee *et al*., (1947) and Chitray (1965) have classified it as herbivore while Das and Moitra (1955) have called it as an omnivore. Chacko and Kuriyan (1948) have not seen it to be either omnivorous or herbivorous. Sinha (1972) studied the food of this fish and called it be an omnivore. Mookherjee *et al*. (1947) recovered only plant food from its gut in Bengal. Das and Moitra (1955) observed that the diet of the fish in Lucknow was dominated by higher aquatic plant with diatoms - bryozoans, desmid, unicellular and filamentous algae. They also said that molluscs formed slightly more than one forth of the total food intake. Chitray (1965) also found mulluscs, diatoms, algae, mud and sand in its gut along with aquatic plants which formed more than 75% of its total food intake. Chacko and Kuriyan (1948) while studying the food of *P. sarana* in fresh - water ecosystem of Madras, found that the fish were mainly feeding on fish remains, diatoms, algae, crustaceans and insects. Sinha (1972) found that the Loni reservoir fish mainly consumed macro - vegetation and molluscs.

Fig. 8(a) and 8(b) show the annual food composition (by volume and occurrence) of P. sarana of the two size groups. It is interesting to note that there is a variation in the consumption of different food items in relation to its size. However, the large fishes tended to consume more mulluscs than that of the small fishes. Similarly small fishes consumed more macro - vegetation than that of the large fishes. Allen (1941). and Thomas (1962) stated in their findings that bigger the size of the fish, bigger of the food item taken. However, it may be added that the food preference in relation to the size of the fish should be reflected in diet. Qayyum and Qasim (1964) while studying the food of O. punctatus found that there was some differences in the food preferrence of the various size groups of fish. Nikolsky (1963) suggested that the composition of the food of fishes with age and size was substantial and adaptation towards the increasing range of food supply of population by enabling the species as a whole to assimilate a variety of food. Thus it may be inferred that the food and feeding of P. sarana varies in different environments. This may be not only due to the availability and abandance of particular food item but also to the ecological and geographical factors. The preference of the food by the fish depends upon the size and age of the fish.

Fig 7(a) and 7(b) show a linear relationship between the gut- length and body - length of the fish. The ratio between the gut and body length of the fish were also calculated which showed slight increase with the increase in the size of the fish. According to Das and Nath (1965) in carnivore this ratio is less than or equal to unity whereas in herbivore and omnivore it is more than unity. Chitray (1965) has reported the length of intestine of this fish thrice as long as the length of the body whereas Agrawal and Tyagi (1969) have observed it to be around one and half times. In the present investigation this ratio was seen to have a mean value of 1.54 which is close to the observation of Agrawal and Tyagi (1969). Sinha (1972) reported the numerical value of this ratio to be 1.59 reflecting an omnivorous feeding adaptation.

Fig 9 shows seasonal feeding intensity of the *Puntius sarana*. The feeding intensity of the fish showed certain variability during various months. The high and low feeding intensity of mature fishes coincided with post spawning and pre-spawning period of the fish. The gradual increase in the feeding activity from September onwards may be because of increased requirement of the food after spawning. However, in immature fishes the high and low feeding activity have been observed in winter and summer respectively. The low feeding ~~ac~~ activity here appeared to be because of the high temperature and low dissolved oxygen concentration in the summer months.

Figs. 10(a) and 10(b) show seasonal variation in food composition (by volume) of *P. sarana*. Similarly figs 11(a) and 11(b) show seasonal variation in food composition (by occurrence) of the fish. The results obtained by these two methods show close agreement. It is clear from the figures that the seasonal variation in the food intake of the fish appears to be related with relative abundance of the food organism in the river at different times of the year.

Considering the feeding habit of the fish, it may be suggested that the fish may be introduced in eutrophic lakes and reservoirs. The fish may also be used for bi-ological control of submerged weeds in lentic water bodies.

CHAPTER- IV

SUMMARY OF THE STUDIES

SUMMARY OF THE INVESTIGATION

The samples of the Puntius sarana for the present investigation were collected from the river Yamuna for a period of one year from September, 1979 to August, 1980. A total of 397 fishes were examined to investigate the growth and food of P. sarana. The investigation may be summarised as follows:

A. THE AGE AND GROWTH OF THE FISH:

1. A linear relationship has been established between the body length and scale radius of the fish. The mathematical relationship were expressed as:

$$Y = -1.6000 + 0.0455\,X \quad \text{(Male Fish)}$$

$$Y = -1.8000 + 0.0459X \quad \text{(Female Fish)}$$

Where Y and X are scale radius and body length of the fish in mm.

2. The males were found to be slightly large than the females of their identical age before maturity while a reverse phenomenon has been observed after they attained maturity.

3. It has been found that the length and weight of the fish increase with age and size showing a curvilinear relationship.

4. It has been found that the specific growth rate of the fish decreases with age and size of the fish. No significant difference between specific growth rate of the male and female

was observed.

5. The length - weight relationship of the fish has been established and the regression of the Log weight on Log length were expressed as :

$$\text{Log } W = -4.7363 + 2.9583 \text{ Log } L \text{ (Male Fish)}$$

$$\text{Log } W = -5.2876 + 3.2002 \text{ Log } L \text{ (Female Fish)}$$

6. The male fishes increased slightly less than the cube of the length while the female fish increased slightly more than the cube of the length.

7. The males were found to be heavier than the females of their identical size in small sized fishes (below 210 mm) while the females were found to be heavier than the males of their identical size in large sized fishes (above 210 mm).

8. The size range at which most of the fishes attain maturity was found to be between 200 mm and 220 mm.

B. <u>FOOD AND FEEDING OF THE FISH:</u>

1. A linear relationship has been established between the gut - length and body length of the fish. The ratio between the gut length and body - length was 1: 1.34 and 1: 1.63 for the small and large fishes respectively. The mean ratio for all the fishes was 1: 1.54 reflecting an omnivorous feeding adaptation.

2. The fish has been found to be a bottom feeder. The main diet of the fish was found to be mulluse, macro-vegetation, plankton and insect larvae.

3. The preferemee of the food was found to be related with the sise of the fish. The large fish preferred to feed on big item of the food (molluses) while the small fish preferred to feed on small food item namely macro - vegetation.

4. The stomach fullness index of the fish has been established which revealed a marked variation in the feeding intensity of the mature fish between the pre and post spawning season. The differences in the feeding activity were also found in immature fishes. This may be due to seasonal variation in temrature and dissolved oxygen concentration in the river.

5. The fish may be used to have a biological control over the sub-merged aquatic weeds of some lentic water bodies.

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Finally, I wish to record my gratitude to my parents who are a constant source of inspiration for me.

Khumar

(Faroogh Khumar)

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APPENDIX

TABLE - I

CALCULATED MEAN LENGTH FOR AGE OF MALE *P. sarana* OF THE RIVER YAMUNA

AGE IN YEARS	CALCULATED MEAN LENGTH IN MM	NO.OF FISH	RANGE IN LENGTH IN MM		STANDARD DEVIATION
			MINI-MUM	MAXI-MUM	
I	120	190	109	132	± 11.2
II	185	175	177	193	± 8.4
III	240	150	230	249	± 9.3
IV	285	101	280	289	± 4.5
V	320	90	314	326	± 5.0
VI	340	40	336	343	± 3.4

TABLE - II

CALCULATED MEAN LENGTH FOR AGE OF FEMALE *P. sarana* OF THE RIVER YAMUNA

AGE IN YEARS	CALCULATED MEAN LENGTH IN MM	NO. OF FISH	RANGE IN LENGTH IN MM		STANDARD DEVIATION
			MINI-MUM	MAXI-MUM	
I	112	202	102	123	± 10.6
II	172	197	164	180	± 8.4
III	250	175	243	259	± 8.1
IV	292	145	286	298	± 5.4
V	330	100	325	335	± 4.4
VI	344	80	340	344	± 3.5

TABLE - III

MEAN CALCULATED WEIGHTS FOR DIFFERENT AGE OF MALE

P. sarana OF THE RIVER YAMUNA

AGE IN YEARS	CALCULATED MEAN WEIGHT IN gm	NO. OF FISH	RANGE IN WEIGHT IN gm		STANDARD DEVIATION
			MINI-MUM	MAXI MUM	
I	26	190	18	36	± 10.3
II	93	175	85	111	± 18.2
III	202	150	184	218	± 16.3
IV	316	101	300	335	± 19.2
V	473	90	455	495	± 18.5
VI	566	40	555	576	± 10.4

TABLE- IV

MEAN CALCULATED WEIGHTS FOR DIFFERENT AGE OF FEMALE *P. sarana* OF THE RIVER YAMUNA

AGE IN YEARS	CALCULATED MEAN WEIGHT IN gm	NO. OF FISH	RANGE IN WEIGHT IN gm		STANDARD DEVIATION
			MINI-MUM	MAXI-MUM	
I	19	202	12	30	± 10.0
II	74	197	60	90	± 15.2
III	243	175	233	265	± 12.5
IV	400	145	385	416	± 15.5
V	592	100	584	601	± 8.6
VI	676	80	670	681	± 5.3

TABLE - V

PERCENTAGE SPECIFIC GROWTH RATE OF *P. sarana* OF THE RIVER YAMUNA

AGE IN YEAR	PERCENTAGE SPECIFIC GROWTH RATE	
	MALE FISH	FEMALE FISH
I - II	67	71
II - III	47	48
III - IV	38	37
IV - V	33	32
V - VI	30	30

TABLE - VI (a)

ANNUAL FOOD COMPOSITION OF THE DIET OF *P. sarana* OF THE SIZE RANGE FROM 202 mm-344 mm AS SHOWN BY VOLUME AND OCCURRENCE METHODS

FOOD ITEMS	BY VOLUME	BY OCCURRENCE
Molluscs	40	25
Macro-vegetation	24	19
Phytoplankton	12	12
Zooplankton	3	7
Insect	8	11
Miscellaneous	3	6
Sand and mud	10	19

TABLE - VI (b)

ANNUAL FOOD COMPOSITION OF THE DIET OF *P. sarana* OF THE SIZE RANGE FROM 112 mm - 200 mm AS SHOWN BY VOLUME AND OCCURRENCE METHODS

FOOD ITEMS	BY VOLUME	BY OCCURRENCE
Molluscs	25	24
Macro-vegetation	45	30
Phytoplankton	15	15
Zooplankton	5	7
Insect	5	8
Miscellaneous	1	7
Sand and mud	4	9

TABLE - VII

MONTHLY VARIATION IN FULLNESS INDEX OF THE STOMACH OF *P. sarana* OF THE RIVER YAMUNA OF THE TWO SIZE GROUPS. (SMALL & LARGE)

MONTH	*P. sarana* (112mm- 200mm)	*P. sarana* (201mm- 344mm)
SEPTEMBER	4.5	6.6
OCTOBER	8.0	13.4
NOVEMBER	10.0	16.4
DECEMBER	12.5	17.7
JANUARY	12.7	20.1
FEBRUARY	10.0	16.1
MARCH	9.2	12.0
APRIL	6.0	10.1
MAY	4.2	6.0
JUNE	4.0	3.3
JULY	4.3	3.5
AUGUST	3.5	4.3

TABLE - VIII (a)

SEASONAL FOOD COMPOSITION OF THE DIET OF *P. sarana* OF THE SIZE RANGE FROM 201 mm - 344 mm AS SHOWN BY VOLUME METHOD

FOOD ITEMS	SEP/ OCT	NOV/ DEC	JAN/ FEB	MAR/ APR	MAY/ JUN	JUL/ AUG
Molluscs	50	35	30	35	40	50
Macro-vegetation	16	25	25	34	29	15
Phytoplankton	12	16	17	9	9	9
Zooplankton	3	4	5	3	2	1
Insect	8	7	8	6	8	11
Miscellaneous	3	2	3	4	2	4
Sand and mud	8	11	12	9	10	10

TABLE VIII (b)

SEASONAL FOOD COMPOSITION OF THE DIET OF *P. sarana* OF THE SIZE RANGE FROM 112 mm - 200 mm AS SHOWN BY VOLUME METHOD

FOOD ITEMS	SEP/ OCT	NOV/ DEC	JAN/ FEB	MAR/ APR	MAY/ JUN	JUL/ AUG
Molluscs	24	24	21	22	24	35
Macro-vegetation	40	35	48	55	50	42
Phytoplankton	18	23	12	12	14	11
Zooplankton	6	7	4	4	-	4
Insect	6	5	7	-	5	3
Miscellaneous	2	1	2	4	5	1
Sand and mud	4	5	6	3	2	4

TABLE- IX (a)

SEASONAL FOOD COMPOSITION OF THE DIET OF *P. sarana* OF THE SIZE RANGE FROM 201 mm - 344 mm AS SHOWN BY OCCURRENCE METHOD

FOOD ITEMS	SEP/ OCT	NOV/ DEC	JAN/ FEB	MAR/ APR	MAY/ JUN	JUL/ AUG
Molluscs	25	26	25	26	24	27
Macro-vegetation	17	20	21	20	21	18
Phytoplankton	11	15	13	12	14	12
Zooplankton	8	10	7	7	6	6
Insect	13	10	11	12	9	14
Miscellaneous	4	5	4	4	4	3
Sand and mud	22	14	19	19	22	20

TABLE - IX (b)

SEASONAL FOOD COMPOSITION OF THE DIET OF *P. sarana* OF THE SIZE RANGE FROM 112 mm - 200 mm AS SHOWN BY OCCURRENCE METHOD

FOOD ITEMS	SEP/ OCT	NOV/ DEC	JAN/ FEB	MAR/ APR	MAY/ JUN	JUL/ AUG
Molluscs	24	23	22	25	19	23
Macro-vegetation	28	30	28	41	25	26
Phytoplankton	12	15	15	14	19	16
Zooplankton	8	10	7	8	-	10
Insect	8	10	7	-	13	10
Miscellaneous	8	5	7	5	12	5
Sand and mud	12	7	14	7	12	10